PROPOSAL

PHYSIOLOGICAL MECHANISMS, ANALYSIS, AND BEHAVIORAL SIGNIFICANCE OF THE ELECTRODERMAL RESPONSE

From

[redacted]

Approved for Release
Date 27 Feb 1979

153

Period of Work

This proposal would cover one year of effort.

Facilities

This work described would be accomplished in the same laboratories of the

In addition to equipment described under that contract, there is now available an impedance bridge, a voltage to frequency converter, electronic counter and ratio detector, an eleven column printer, and an expanded digital logic system for on-line analysis.

Amount of Support

An estimate of costs is attached. Contractual financial arrangements are proposed as exist under the current contract.

Reports

It is proposed that scheduling of progress reports be continued on the same basis as described in

Principal Investigator

PHYSIOLOGICAL MECHANISMS, ANALYSIS AND BEHAVIORAL SIGNIFICANCE OF THE ELECTRODERMAL RESPONSE

I. INTRODUCTION

Reference is made to the description of the background for this study and of the proposed work as described under contracts [redacted] initiated in June 1966 and [redacted] a one year continuation of the earlier contract. Further reference is made to Interim Reports dated February 15, 1967 and October 25, 1967. The initial efforts were directed toward a study of the physiological mechanisms underlying the electrodermal response in an effort to provide a rational basis for quantitative treatment and interpretation of electrodermal measures. These findings provide evidence to support the conclusion that the electrodermal system is a two-component system in which two processes under autonomous control sometimes function synergistically, sometimes independently. Evidence for this was drawn from microelectrode observations on sweat ducts and areas between sweat ducts, observation of potentials from the nail plate, the differential effects of aluminum and of sodium on the positive and negative potential waves, optical recording of a sweat reabsorption phenomenon and the association of this phenomenon with the positive wave and finally the behavior of a locally induced positive potential response. From these and other pieces of evidence it was concluded that information regarding the activity of the second hypothesized component was to be found in the shape of the recovery limb of the exosomatic

response, the speed of recovery increasing in accordance with such activity. Various methods were developed for the quantitative treatment of the time constant of this recovery limb (it was treated as an exponential decay) and manual methods were developed for its measurements. Tests of the strength of this measure revealed that it had an impressive capacity for discriminating states of activation and application to a task. Moreover, it also was capable of distinguishing between individuals having different behavioral patterns in a way far superior to amplitude measures. These results were described in the last report (October 1967).

Since that report, efforts were concentrated on three areas:

a) Physiological: Despite conflicting evidence, the likelihood that the electrodermal response contains a component of vascular origin kept reappearing. A study was consequently undertaken involving the application of venous cuffs (for engorgement of surface vessels) and arterial cuffs (for generation of hypoxia) to determine the nature of any local process incident to the removal of these conditions. Great care was exercised to eliminate artifacts which might render results spurious. The conclusion ($P < .01$ in two separate comparisons) is that a local potential shift attends the termination of either venous or arterial occlusion. Because of the significance of this finding to electrodermal interpretation, these studies will be pursued further.

b) Measurement of the recovery limb time constant: Attention was given to those circumstances in which measurement of the time constant by template is in part confounded by the superposition of one response upon the recovery limb of another. A rationale was provided for the required correction in such measurements

and a validation obtained from mathematical determinations using measurements of the derivatives.

An area given heavy emphasis was the automatic determination of the recovery limb time constant. A satisfactory system was achieved in which the time constant is printed out on-line. The negative first derivative of the skin conductance response is divided by the positive second derivative at a point 0.6 seconds after the peak of the primary wave. These results bear a very satisfactory relation to those obtained by template measurement.

c) Behavioral: The characteristics of the recovery limb time constant have been studied in a human population in an effort to determine their individual specificity, their relationship to type of behavior in process, and their reliability over repeated testing. Since the automatic system was not operational at the time of these runs, data were obtained by template measurement. Runs on each of 12 subjects taken for five consecutive weeks and under eight different conditions showed that there were significant individual characteristic differences in the speed of recovery, even though for any given individual the rank order of his recovery speeds under different experimental situations was similar to that of the group. The change in time constant as a function of 8 different conditions was tested on a population of 21 subjects with results substantiating the earlier report on 9 subjects.

Data on another population of 50 subjects were examined for the relationship between the recovery limb time constant for a given individual and the time it took his cutaneous vasoconstriction to recover (recovery half-time) after a stressful task. The rationale for examining this relation was the important behavioral significance

believed to lie in the rate at which an individual can "throttle back" after mobilizing to deal with an emergency. Surprisingly the shorter the time constant during the task, the longer the time required for recovery from vasoconstriction ($P < .01$). This may imply that subjects who are able to mobilize fully for a task (interpretation of short time constant) remain mobilized longer after its cessation. Since subjects with short time constants also showed better maintenance of an inhibitory set in a knob-turning task, it is possible that such individuals are characterized by higher neurophysiological inertia.

One of the tasks required of subjects in these studies was to count backwards from 500 as rapidly as possible, by sevens. The total number span and number of errors in a fixed time (2 minutes) were compared with the characteristic time constant during this task. Shorter time constants were associated with faster rates of calculation and fewer errors. It can thus be concluded that the electrodermal recovery rate of an individual is not only predictive of his physiological performance but (at least in this task) of motor and cognitive performance as well.

II. PROPOSED INVESTIGATIONS

Although most of the effort proposed for an additional year of support would be directed toward study of the electrodermal recovery limb as a behavioral indicator, the recent results which suggest the involvement of a vascular component point up the desirability of further effort in this area. The relative portion of work devoted to these respective projects can be varied in accordance with the preference of the contracting agency.

A. Studies on the Electrodermal Recovery Limb

1. Extension of studies already under way will be pursued in order to answer several procedural questions involved in the use of the time constant measure. These include:

(a) To what extent is the time constant of an individual characteristic? Can the same principles be applied to interpreting intra-individual shifts in this measure for individuals having different "characteristic" recovery rates?

These questions will be answered by using an array of stimuli which offer the least likelihood that the emotional or behavioral response will be idiosyncratic. These stimuli will be such as to elicit preparation for action (e.g. a simple reaction time effort), preparation for sensory intake (e.g. a perceptual task), or fear (e.g. of electric shock due to "possible equipment failure").

(b) How does the behavior of the time constant relate to that of other electrodermal indices and of other autonomic measures. In all cases during the projected standardization study, measures of heart rate, digital plethysmograph, a skin potential and respiration will be obtained. Two channels of F-M tape recording are presently available for storage of data for later automatic analysis and it is proposed to set up an additional two channels of low cost tape recording to complete the battery. Special purpose computation will be performed prior to any A-D conversion so that computation will require

only minimal computer time or none-at-all. Analysis of covariance (to correct for base level effects) and correlations of rank order concordance will be used to answer questions of covariation.

(c) How does the predictive ability of isolated responses compare with that of responses superimposed on the recovery limb of a preceding response or on a drifting base-line? Responses will be elicited either singly or in close sequence by using either single stimuli or trains of stimuli. It is to be expected that the time constants of a succession of responses to the same stimulus should be relatively similar to that for an isolated stimulus of similar quality. The corrections necessary to give such a population of responses the least variance will be examined by automatic techniques.

(d) Can the time constant be automatically determined without the use of the second derivative? Although a clean record of the second derivative may be easily obtained with the technique used at this laboratory, it has usually been looked upon as difficult to achieve because of the enhancement of noise in such records. To give this system maximum operational feasibility, efforts will be made to obtain the time constant measure with the first derivative alone. Efforts toward this end are under way and a possible solution is being examined.

2. Behavioral Significance

(a) To what extent can an individual's characteristic time constant be used to predict performance? Are there certain categories of performance for which it is a better predictor than others. To what extent can the time constant obtained under one stimulus situation be useful in predicting behavior or performance

in another situation. The answers to these questions will be investigated primarily by physiological measurement during an array of tasks which afford samples of the individual's performance in different areas (psychomotor, perceptual, cognitive and combinations). A stress variable, such as a conflicting stimulus field will be employed during some of these tasks to determine the degree to which the time constant measure is predictive of how performance will be impaired by such stresses.

(b) How well can this index, in conjunction with others help in the identification of emotional shifts. This area will be investigated in an interaction situation in which the subject is being interviewed. In this situation a pre-assessment will be made of subject material which can be calculated to produce a mild emotional response and of other material which is bland for the subject. The simplest form of this will be to determine the names of persons closely related to the subject and of others unknown to him, or the name of the vehicle owned by the individual or his address. These will be brought into an otherwise bland interview and their occurrence signalled on the physiological recording. Analysis will consist of a comparison of the time constant and also of other physiological measures during the bland and the especially significant periods, using the same analytic techniques as for part 1.

B. Investigation of a possible vascular component in the electrodermal response.

1. The possibility that a vascular component contributes significantly to the skin potential response will first be examined by local (iontophoretic)

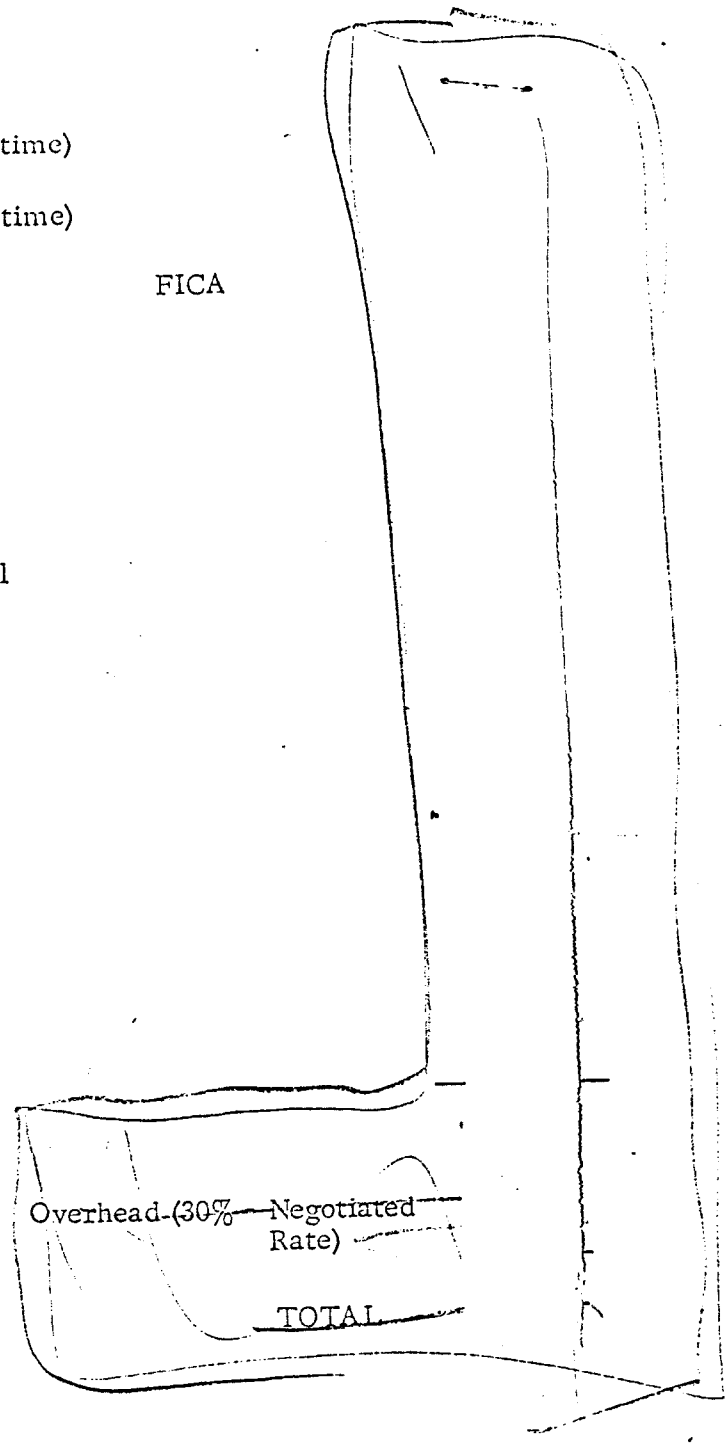
introduction of an adrenergic blocking agent, bretylium tosylate. This agent was shown by Lader and Montagu to eliminate cutaneous vasomotor activity but not skin conductance responses. He did not examine potential changes. Thus a vasomotor component may be responsible for an appreciable potential shift but only a small conductance shift (as occurs on the arm and leg). Consequently not only will potentials be recorded under this condition and compared with a control site but a closer statistical examination will be made of the extent to which conductance responses are possibly attenuated.

2. Impedance measures at very high frequency on a saline soaked site should provide a measure of series ohmic resistance. Soaking of the site should reduce or abolish the contribution to changes in such resistance by variation in the length of the sweat column and hence should reflect blood volume change (as in impedance plethysmography). Potentials will be measured concurrently at the same site by the use of a filtering system now being used at this laboratory. Thus possible correlation of impedance responses with positive or negative potential components will be examined and the behavior of both will be examined during occlusion or temperature shift.

3. The skin will be punctured with microelectrodes with care to prevent damage to blood vessels. Under these conditions, the principal investigator has in the past been able to record changes which persisted after puncture, but uncertainties about activity at the reference site put these experiments in doubt. The present design calls for two perforating capillary microelectrodes, one serving as the reference for the other. The experimental site may then be cooled, heated,

engorged or occluded, and any potential responses would most likely be attributable to vasomotor activity. If positive results are obtained, in order to eliminate possible contribution from the body of the sweat gland, these same experiments will be performed after local atropine block.

Proposed Budget



Personnel

Principal Investigator (Part-time)

Research Assistant (Full-time)

FICA

Equipment

Cardiotachometer Coupler

Tape recorder - Dual Channel

Expendable Supplies

Subject Fees

Computer Time

Travel to visit related projects

Overhead (30% Negotiated Rate)

TOTAL